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Final Technical Report on NCC 2-739:
Detection and Analysis of Aircraft-Produced Particles in the Stratosphere: Instrument Development

Report Covering Time Period:
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Objectives of the Cooperative Agreement

The objectives of the work funded by this cooperative agreement were to develop two instruments to study aircraft particle emissions in the stratosphere and to package the two instruments in one case for placement in the ER-2 in the left wingpod. The first instrument is a dual channel condensation nucleus counter (CNC). The CNC detects particles larger than 0.008 μm in diameter. One channel of the dual channel instrument operates normally, counting all particles which reach the instrument. The second channel provides for heating of the sample so that the number of particles which survive heating to various temperatures can be counted. The second instrument is an aerosol sampler. The proposed instrument was to use an electrostatic sampler, however that design failed in laboratory tests and an impactor sampler was substituted.

The instrument was to permit detection and sampling of particles emitted by aircraft. It was reasoned that the soot emitted by aircraft engines would not be volatile in the heated inlet. Thus it was thought that samples collected while non-volatile particles were sampled would contain particles emitted by aircraft. Subsequent analysis by analytical electron microscopy was to provide insight concerning the nature of such particles.

Accomplishments during this Cooperative Agreement

Design of the two channel CNC. Design changes resulting from the previous grant (NCC2-666) were implemented. This resulted in a more compact sample flow meter and vertical saturator and thus permitted the aerosol sample heater to be efficiently added to the sample line. The heater is capable of heating the aerosol sample to 200 C. Figure 1 shows the detection efficiency of the ER-2 CNC II as a function of particle size and pressure.

Design of the aerosol collector. The electrostatic collector was modeled mathematically and built. However, laboratory tests showed that unanticipated corona effects prevented the collector from performing as designed. Thus the electrostatic collection technique was abandoned. A thin plate impactor was designed to permit small particles to be collected and analyzed. Figure 2 shows a schematic of the impactor collector system. It involves an orifice to reduce the pressure of the sample without losing a significant fraction of the sampled particles. Then the particles are collected in a thin plate impactor with a transmission electron microscope grid as an impaction plate. A multiple sample holder accommodates 24 samples. The sampler is under computer control and is changed in flight so that up to 24 samplers may be collected in a flight. Table 1 shows the impactor cut point for various ambient pressures. The impactor collects 50% of those particles which have a diameter equal to the impactor cut point and the collection efficiency increases with particle diameter.

Table 1. Impactor Cut Points as a function of Ambient pressure.

| <u>Ambient Pressure</u> | <u>Impactor Cut Point</u> |
|-------------------------|---------------------------|
| 350 mb | 0.064 μm |
| 222 mb | 0.042 μm |
| 135 mb | 0.031 μm |
| 94 mb | 0.021 μm |
| 77 mb | 0.018 μm |

Fabrication and integration of the instrument. The ER-2 CNC II and MACS was constructed following the ER-2 investigators hand book and was integrated into the ER-2 payload.

Conclusions. The objectives of the cooperative agreement were met by the construction of the ER-2 CNC II and MACS.

Bibliography.

No publications resulted from this work. Since the ER-2 CNC II and MACS were used in the Stratospheric Photochemistry, Aerosol and Dynamics Expedition of 1993 and the Airborne Southern Hemisphere Ozone Experiment of 1994, data acquired with the instruments will be reported in the literature.

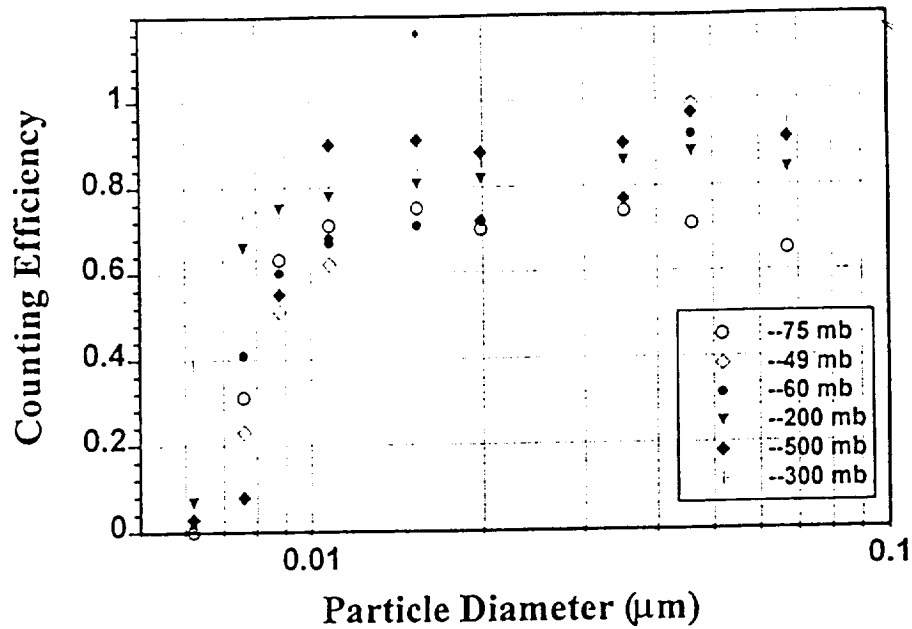


Figure 1. Efficiency of ER-2 CNC II as a function of particle size and pressure. Particle concentration determined with an electrometer.

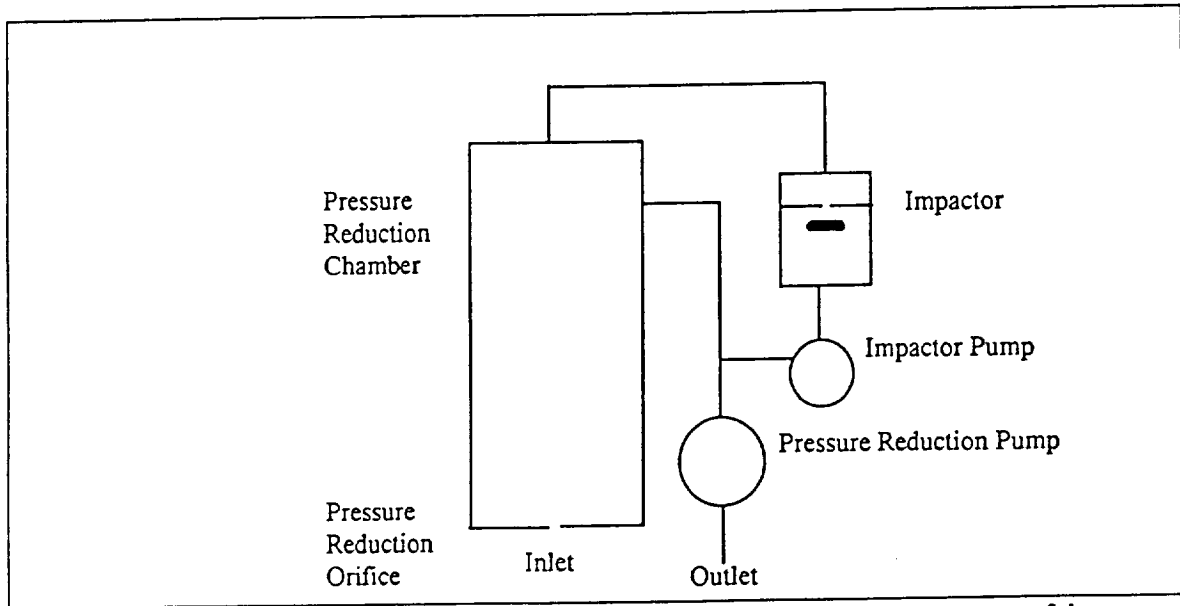


Figure 2. Diagram of the low pressure, thin plate impactor used in the MACS. The pressure of the pressure reduction chamber is controlled at approximately 0.5 of ambient pressure and the flow out of the impactor pump is controlled to provide the cutpoint indicated in table 1.